Unfolding – A Simple Library for Interactive Maps and Geovisualizations in Processing

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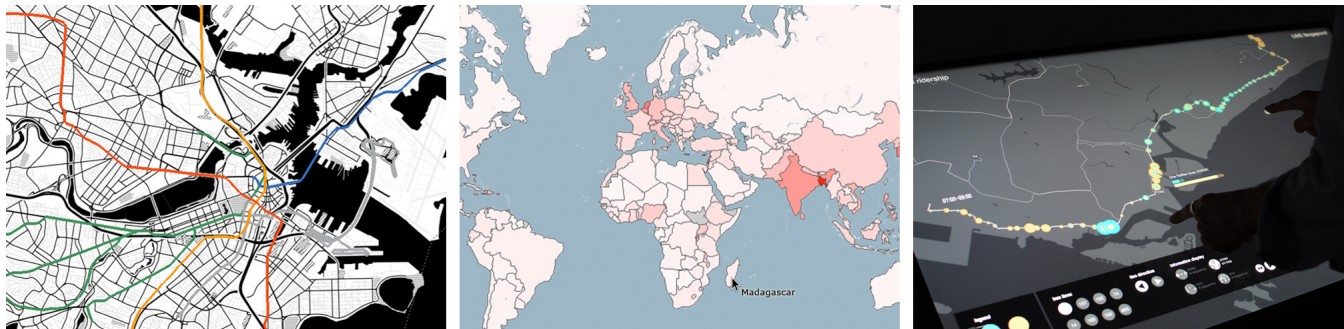
Fig. 1. Three applications created with Unfolding: An animated map showing subways in Boston (left), an interactive choropleth map showing population density (middle), and a visualization showing public transit trips in Singapore for a multitouch tabletop (right).

Abstract—Many thematic maps and geovisualizations nowadays are being created by designers, journalists, and other non cartographers. Yet, with existing tools it is often difficult to create interactive data visualizations tailored for a particular domain or a specific dataset. We present Unfolding, a library to simplify the creation of interactive maps and geovisualizations. Unfolding provides an API to quickly create and customize visualization applications. In this paper, we introduce the design and functionality of our library. We demonstrate its usability through a collection of examples, and confirm the apparent need of such map library by describing its acceptance in the community.

Index Terms—Library, Toolkit, Software Development, Geospatial Data Visualization, Interactive Maps, Interaction Design.

INTRODUCTION

Visualizing data with geo-spatial properties has become more important and prevalent due to the wide spread dissemination of devices, sensors, databases, and services with references to the physical world. Successful geo-visualizations employ established techniques, but tailor the visualization to the application domain and to the specific dataset. Standard GIS software often does not allow this adaptation and simplification. Thus, custom software has to be created. Some existing data visualization libraries (e.g. d3 [1], Prefuse [3]) support basic map functionality, but lack specifics for geovisualizations. With Unfolding, we aim to bridge the gap between traditional and novel visualizations by easing the creation of rapid design experiments for geo-spatial data.

1 DESIGN OBJECTIVES

Unfolding is a library for Processing, a programming language to create interactive graphics, which is used for learning, prototyping, and production [5]. In the same vein, Unfolding was developed with the main goals of learnability, simplicity, and extendibility.

To support the first goal, the library comes with extensive documentation, mostly in the form of tutorials and example code. The library uses a simple programming interface (API) to support the second goal. Users can create interactive maps in very few lines of code (see Code Sample 1). And thirdly, the library provides reusable components, and employs a software architecture allowing to extend its functionality in order to create advanced visualizations.

For creating sophisticated geovisualization applications, reasons to use Processing instead of web based scripting languages include

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the abilities to use OpenGL for high performance visualizations, and to create multitouch interactions for public space applications.

2 FEATURES

Unfolding supports most basic techniques for interactive maps such as zoom and pan, but also other common but more advanced techniques such as Overview+Detail, i.e. showing a large scale map view while keeping the context by displaying the selected region on a large scale map. Furthemore, it eases visualizing tempo-spatial data.

In the following we describe some of the basics of creating interactive applications with the library.

2.1 Basic map features

In just three lines of code, a developer can create an interactive map, and display it in full canvas size. The library uses the so-called Slippy Map technique [2], which uses a tile-based algorithm with map tiles of 256x256px for different fixed zoom levels.

The map is displayed in a default style with cartographic data from OpenStreetMap and tiles from Cloudmade, a web map tiles service. To use another map style, users can specify a different provider as second parameter when constructing an UnfoldingMap. Unfolding provides eight pre-configured map tile providers for educational purposes. Users can also create their own map provider to use customized map styles adapted to the prerequisites of their visualization. For instance, if the objective of the map is to support general spatial recognition while being discreet enough to not hinder the display of the data and interface layers, a minimal style with selected geographical features could be employed.

By default, end users can directly interact with the map. These interaction patterns are based on standard map manipulation techniques by mainstream map services.

Programmatically focusing on a map section allows developers to directly draw the user's attention to a specific region, e.g. when the dataset is for selected countries only.

2.2 Basic visualization of geo-spatial data

A user can convert a screen position to a geo-location, and vice versa. For example, a code snippet of three lines displays latitude and longitude of the current mouse position as a text label. More common is to display geo-spatial data on a map. For this, developers can use Unfolding's built-in marker mechanism. To display a simple location marker at the correct screen position, one can create and add a SimplePointMarker to the map.

Unfolding provides a default marker style, and has point, line, and polygon markers out of the box. The library also allows reading standard data formats, and automatically creating the respective graphical representations. The provided data readers support basic functionality, and do not fully implement the respective specifications. The GeoJSON parser supports most features, while the GeoRSS reader supports only Simple and W3C Geo, but not GML, and the GPX reader only enables reading track points. The aim was not to re-implement functionality developers can use and integrate from more sophisticated GIS libraries, but to enable getting quick results in a rapid prototyping approach.

```
UnfoldingMap map;
void setup() {
  map = new UnfoldingMap(this);
  MapUtils.createDefaultEventDispatcher(this, map);
  List features = GeoRSSReader.loadData(this, "quakes.xml");
  map.addMarkers(MapUtils.createSimpleMarkers(features));
}
void draw() {
  map.draw();
}
```

Code Sample 1. A full application loading and displaying earthquake data on an interactive map.

The marker style can be customized, or completely implemented by the designers. The second option allows using data glyphs such as donut charts, or any other data display technique. For instance, by mapping a value to the brightness value of a polygon marker one can create simple choropleth maps. The example in Fig.1 (middle) shows an interactive version displaying population density of the world. Users can select single countries by hovering over (one of) their polygons, and additional data can be display on demand.

3 APPLICATIONS

We follow the argument of the authors of the widespread Protovis visualization toolkit that one of the main values of a toolkit lies in the design and dissemination of successful visualizations [1]. Thus, we describe two projects, selected to represent the spectrum of how people are using the library and to exemplify various features.

The first example is Muse, a visualization for exploring geo-spatial networks in scientific communities (Fig. 2). Besides for the background map, Unfolding is used to display universities and research institutions as scaled circles representing number of papers, and the connections between them based on co-authored publications. User studies have shown that casual users in conference settings were satisfied with the ease of use of this multitouch visualization [4].

The second example is the Live Singapore ridership application (see Fig. 1 right). It shows bus passenger flows in three connected visualizations, and allows users to interactively explore bus lines and areas of interest.

One of the challenges in developing this visualization was to create a performant data display method in order to keep high responsiveness on every user interaction.
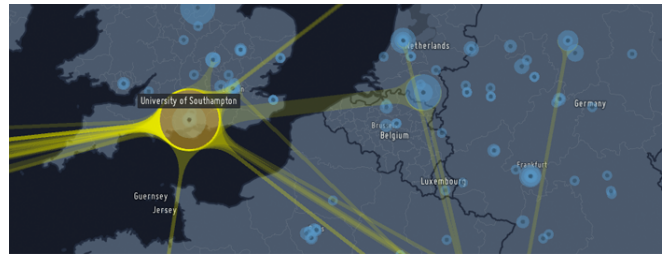

Fig. 2. Showing weighted connections between institutions.

Users can slide through the time dynamically which is directly reflected in the geo-spatial markers. Unfolding supports traversing the visualization pipeline in an efficient way, so that after users adapt the time range the data gets newly aggregated and displayed nearly instantaneously.

4 EVALUATION

The use in courses teaching basics on geospatial data visualization allowed us to observe how beginners were using the library, and to simplify the API and improve the documentation. Since 2009, Unfolding has been used in six courses at FHP, and two at IUAV (by the authors). Besides, it has been endorsed in various other university courses, in departments ranging from interaction design to computer science to urban studies.

Unfolding was publicly released in August 2011, and the first public version 0.8 downloaded over 3000 times in the following twelve months. The next version 0.9 was published end of September 2012 and downloaded over 1500 times in the first two months (as per 22nd November 2012). We collected over 40 projects which were accessible on the web and referred to the Unfolding website, or were described in publications.

We are currently running a summative user study as an online survey. The survey is partly based on an ISO standard to evaluate software quality, and influenced by related surveys (though we did find very few user studies for visualization libraries). The online form consists of a questionnaire on library and feature usage, and satisfaction on several aspects such as learnability and suitability. We will report on the results in an upcoming paper.

5 CONCLUSION

We presented a library to create interactive maps and geovisualizations. Both creating our own applications, as well as collecting feedback from visualization projects by others has helped us to verify and adapt the objectives of the library, and to repeatedly refine its function range. We see the use in various courses, in student, research and commercial projects as first indicator for the learnability and usability of the library.

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